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WATER QUALITY STUDY, OZARK WELL FIELD, ARKANSAS RIVER BASIN, ARKANSAS

Federal Water Pollution Control Administration
Dallas, Texas

May 1967

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WATER QUALITY STUDY
OZARK WELL FIELD
ARKANSAS RIVER BASIN
ARKANSAS

**A Study of the Effects of the
Arkansas River Multiple-Purpose Plan
on the Ozark Well Field**

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UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
South Central Region
Dallas, Texas

MAY 1967

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WATER QUALITY STUDY

OZARK WELL FIELD

ARKANSAS RIVER BASIN

ARKANSAS

Abstract

An investigation has been completed which discloses that quality changes in the city of Ozark's municipal water supply caused by completion of the Arkansas River Multiple-Purpose Plan will not damage the supply but will actually be beneficial.

Prepared for

DEPARTMENT OF THE ARMY

U.S. Army Engineer District

Little Rock, Arkansas

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
South Central Region
Dallas, Texas

MAY 1967

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I. INTRODUCTION

Request and Authority

In a letter dated August 18, 1964, the U.S. Army Engineer District, Little Rock, Arkansas requested the Public Health Service, Department of Health, Education, and Welfare to make necessary studies to determine what effect the Arkansas River Multiple-Purpose Plan would have on the city of Ozark well water supply.

The subsequent study was made in accordance with provisions of the Federal Water Pollution Control Act, as amended, (33 U.S.C. 466 et seq.) whereby, authority was given to conduct investigations relating to the causes, control, and prevention of water pollution.

Effective December 31, 1965, Section 2 of the Water Pollution Control Act, as amended by Public Law 89-234, established the Federal Water Pollution Control Administration as an operating agency of the Department of Health, Education, and Welfare. Under Reorganization Plan No. 2 of 1966, the Administration was transferred to the Department of the Interior effective May 10, 1966. As a result of these changes, responsibility for completing this study has been transferred to the Federal Water Pollution Control Administration in the Department of the Interior.

Purpose and Scope

The purpose of this study is to determine what effect the Arkansas River Multiple-Purpose Plan will have on the quality of the city of Ozark's well water supply. Particular attention was directed toward the Ozark Lock and Dam project which is now under construction since the well field will adjoin the reservoir.

This study includes an estimation of the chemical quality of water to be impounded in the Ozark Reservoir, the probable withdrawal rate from the wells for municipal water for the year 1970, the chemical quality that can be expected in the municipal water supply, and the extent of damages, if any, that may happen to the supply as a result of the completion of the Arkansas River Multiple-Purpose Plan.

Acknowledgments

The cooperation of the following agencies is gratefully acknowledged:

U.S. Army Engineer District, Little Rock, Arkansas
Arkansas District, U.S. Geological Survey, Little Rock, Arkansas
Arkansas State Board of Health, Little Rock, Arkansas
Arkansas Water Pollution Control Commission, Little Rock, Arkansas

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The ground water reservoir that supplies the city of Ozark's well field is now recharged primarily by infiltration of precipitation, and partially by seepage of river water induced by drawdown of the ground water piezometric surface by pumping. The U.S. Geological Survey found that during 1965, about 52 percent of the water pumped was induced from the river.

2. Since a large portion of the water pumped from city wells is river water that has been induced into the ground water reservoir, the quality changes in Ozark's municipal water supply are directly related to the sequence of quality changes in the river water.

3. In the Arkansas River at Ozark, high mineral concentrations occur during low flow periods and low concentrations occur during high flow periods. Prior to completion of reservoirs included in the Arkansas River Multiple-Purpose Plan, extreme variations in flow resulted in wide fluctuations in mineral quality.

Conclusions

1. The Arkansas River Multiple-Purpose Plan, after completion, will improve the mineral quality of Arkansas River water at Ozark. This improvement is attributable to the averaging of mineral concentrations through upstream flow regulation.

2. The U.S. Geological Survey has projected that, under postconstruction conditions with the estimated 1970 pumping rate, an average of 93 percent of the water pumped by city wells will be induced from the river. It has been estimated that pumpage from the Ozark well field will increase from 121.3 million gallons in 1965 to 146 million gallons in 1970.

3. Under 1970 pumping conditions, chloride and total dissolved solids concentrations in Ozark's municipal water supply will often exceed desirable (250 milligrams per liter (mg/l) chloride, and 500 mg/l total dissolved solids) maximum limits either with or without completion of the Arkansas River Multiple-Purpose Plan. However, a better quality water will be provided after the plan is completed since maximum mineral concentration levels

will be reduced and fluctuations in mineral concentrations will be stabilized making changes in the taste of the water less noticeable.

4. Changes in the quality of water pumped from Ozark's well field aquifer that may be attributed to the Arkansas Multiple-Purpose Plan will not preclude further use of the aquifer for municipal water supply purposes.

III. THE STUDY

The city of Ozark, Arkansas with a population of about 2,000, owns and operates six water wells in a field near the city. The field is located in an alluvial area that borders the right bank of the Arkansas River between river mile 308 to 313.5 (see figure III-1 following page V-1).

One of the Arkansas River Multiple-Purpose Plan structures, the Ozark Lock and Dam, will be constructed at river mile 308.9 and will impound water contiguous to the alluvial area at an elevation of 372 feet above mean sea level (m.s.l.). This elevation is about 29 feet higher than the 1965 average river stage. 1/

Impoundment at this location could have an adverse effect on the Ozark water supply since raising the surface water elevation could cause large quantities of river water with high mineral concentrations to flow from the impoundment into the well field aquifer. The possibility that the quality of water in Ozark's municipal supply would be impaired to such a degree that it would be necessary to locate a new source of supply made it necessary to determine the degree of water quality damage, if any, that would occur.

Extensive studies were made to determine the changes that could be expected in the quality of water in Ozark's supply. These studies were designed to define the extent of changes in mineral concentrations. Increases in organic material concentrations or bacteriological densities due to the expected modification of hydrologic conditions was considered highly improbable.

Chemical quality analysis was restricted to a detailed study of chlorides and total dissolved solids. Concentrations of these constituents in Arkansas River water have frequently exceeded desirable limits in the past. Other constituents are normally within acceptable limits.

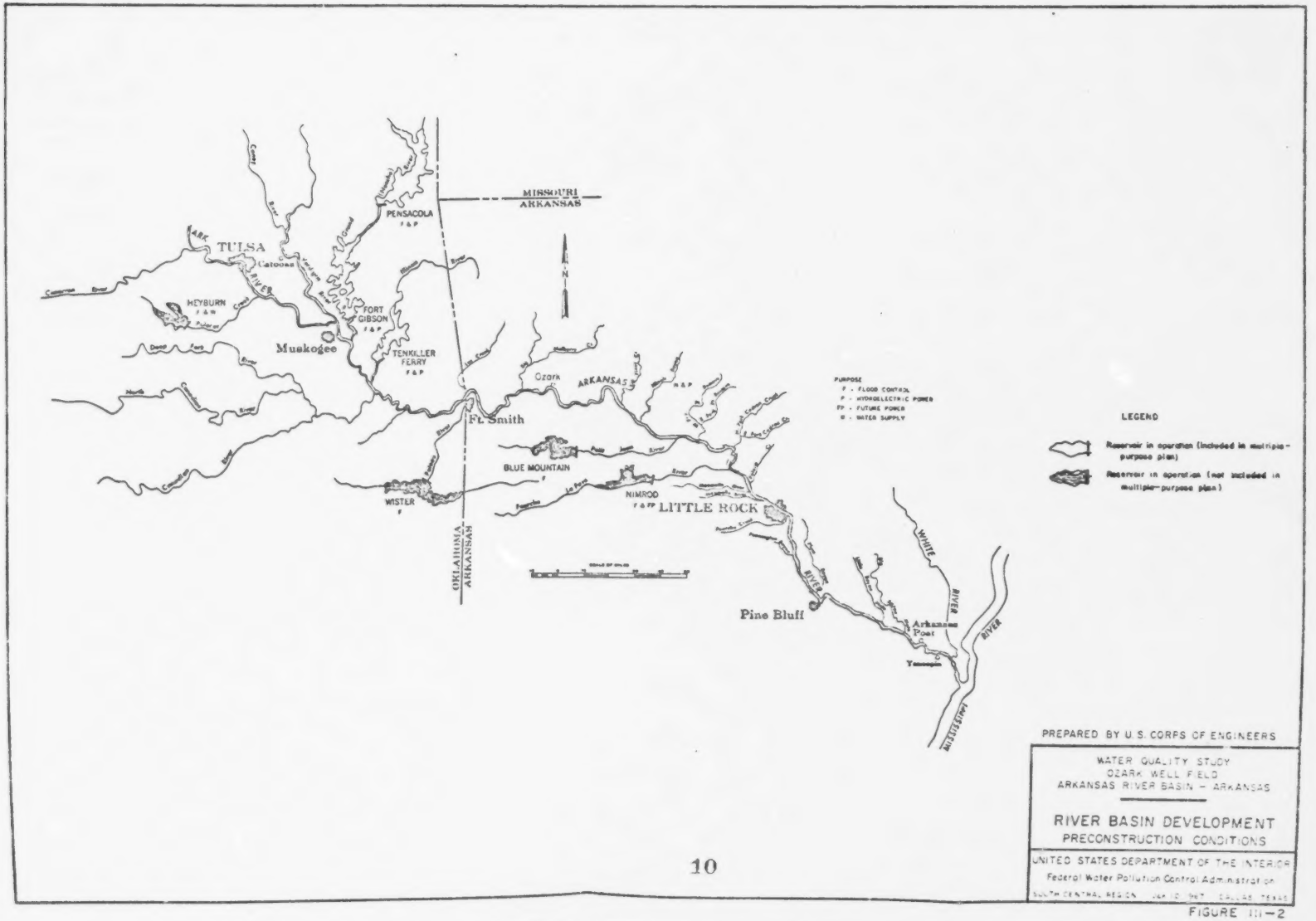
The objective of the study was to determine what effect the multiple-purpose plan would have on water quality in Ozark's supply. To accomplish this objective it was necessary to estimate what quality well water would exist at a specific point in time, both with and without the project in operation. The year 1970 was chosen as the point in time to be used for quality comparisons because it is expected that the entire multiple-purpose plan above Ozark will be operational by 1970. It was assumed that the aquifer hydrology would be in adjustment with the postconstruction river stage.

Since the Ozark well field aquifer is hydraulically connected with the Arkansas River, well water quality is directly associated with the interrelationship of the aquifer hydrology and the sequence of quality changes in river water. This interrelationship was

defined by the U.S. Geological Survey by means of an electrical analog model of the aquifer. 1/ Estimates of river water quality (see Appendix A) and 1970 pumping rates (see Appendix B) were then used in the analog model to predict what the quality of the well water would be at pumping rates that will prevail in 1970.

River water quality estimates were used for two different conditions: The "preconstruction" condition (basically river basin conditions prior to 1963) when river stages and river water quality were only partially regulated by structures considered to be part of the Arkansas River Multiple-Purpose Plan of development; and, the "postconstruction" condition when the planned structures will provide extensive regulation of both river stages and water quality. Figure III-2 shows the river basin development considered in preconstruction analyses and figure III-3 shows the basin development considered completed in postconstruction analyses.

The preconstruction and postconstruction well water quality data developed by the U.S. Geological Survey were then used to determine the extent of quality changes that would be caused as a direct result of the completion of the multiple-purpose plan.



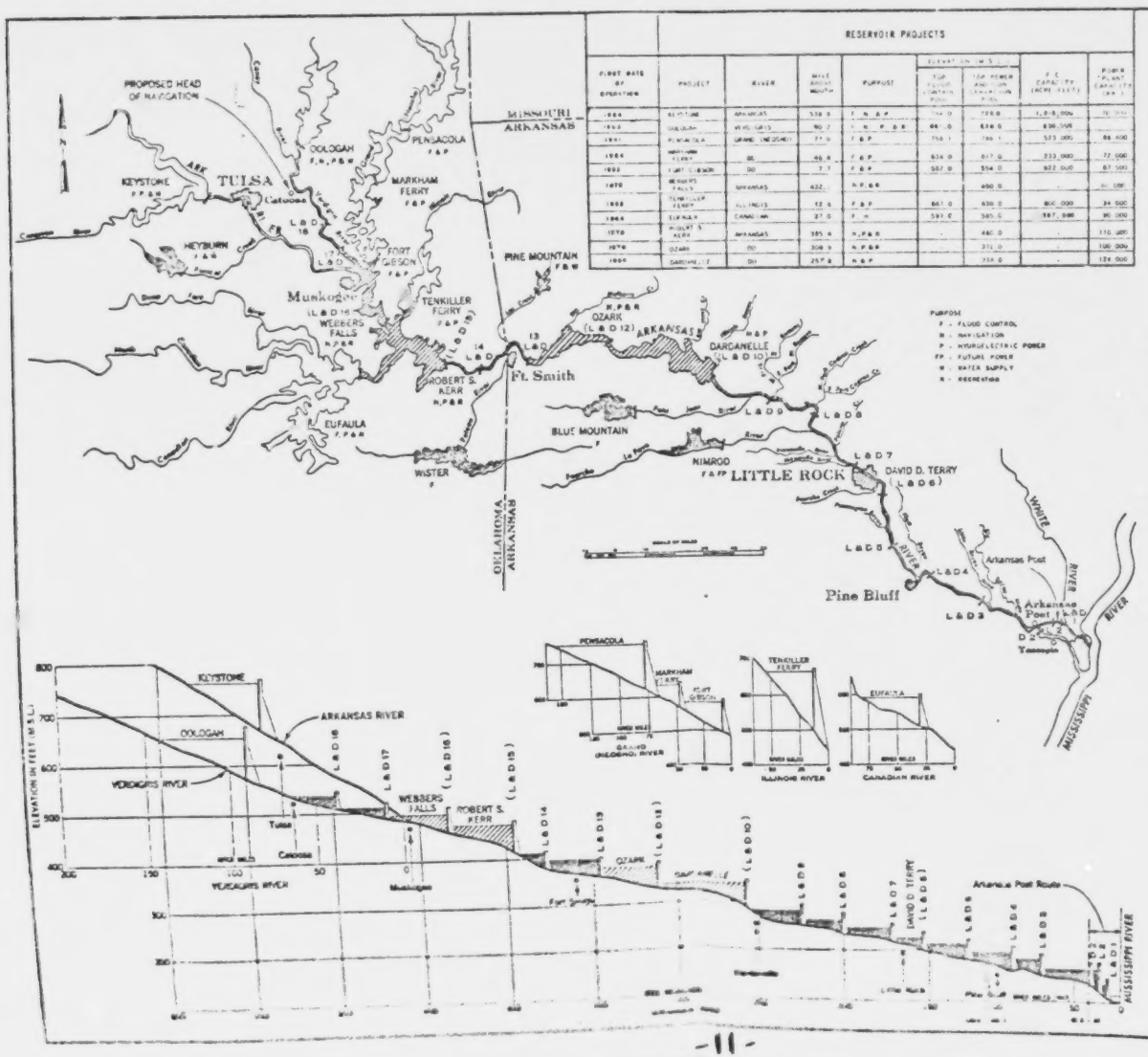
PREPARED BY U.S. CORPS OF ENGINEERS

WATER QUALITY STUDY
OZARK WELL FIELD
ARKANSAS RIVER BASIN – ARKANSAS

RIVER BASIN DEVELOPMENT
PRECONSTRUCTION CONDITIONS

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTH CENTRAL REGION JAN 10 1967 DALLAS, TEXAS

FIGURE III–2



RESERVOIR PROJECTS

FIRST DATE OF OPERATION	PROJECT	RIVER	MILE ABOVE MOUTH	PURPOSE	ELEVATION (M.S.L.) TOP FLOOD CONTROL POOL	ELEVATION (M.S.L.) TOP POWER AND/OR CONSERVATION POOL	F.C. CAPACITY (ACRE FEET)	POWER PLANT CAPACITY (KW)
1964	KEYSTONE	ARKANSAS	538.0	F, N & P	744.0	722.0	1,810,000	70,000
1963	OOLOGAH	VERDIGRIS	90.7	F, N, P & R	661.0	634.0	630,500	
1941	PENSACOLA	GRAND (NEOSHO)	77.0	F & P	756.1	700.1	523,000	86,400
1964	MARKHAM FERRY	GR	46.8	F & P	634.0	617.0	333,000	72,000
1953	FORT GIBSON	GR	7.7	F & P	587.0	554.0	622,000	97,500
1970	WEBBERS FALLS	ARKANSAS	422.	N, P & R		490.0		64,000
1958	TENKILLER FERRY	ILLINOIS	12.6	F & P	661.0	638.0	806,000	34,000
1964	EUFAULA	CANADIAN	27.0	F, N	593.0	585.0	387,000	90,000
1970	ROBERT S. KERR	ARKANSAS	385.6	N, P & R		480.0		110,000
1970	OZARK	DO	308.9	N, P & R		371.0		100,000
1969	DARDANELLE	DO	257.8	N & P		338.0		124,000

NAVIGATION PROJECTS (River and Harbor)

FIRST DATE OF OPERATION	STRUCTURE	MILE (1962 SURVEY EXCEPT AS NOTED)	LOCK FLOOR ELEVATION (FEET M.S.L.)	LOCK PASS ELEVATION (FEET M.S.L.)
1970	DAM NO. 18	36.3	500.0	513.0
1970	LOCK AND DAM NO. 16	34.9 DC	537.0	551.0
1970	DAM NO. 17	12.9 DC	571.0	590.0
1970	LOCK NO. 15	8.2 DC	581.0	595.0
1970	WEBBERS FALLS LOCK AND DAM NO. 16 (1)	632.3 ARKANSAS R	480.0	496.0
1970	ROBERT S. KERR LOCK AND DAM NO. 15 (1)	395.4 DC	496.0	512.0
1970	LOCK AND DAM NO. 14	375.1 DC	472.0	492.0
1970	LOCK AND DAM NO. 13	344.3 DC	787.0	317.0
1970	OZARK LOCK AND DAM NO. 12 (1)	308.9 DC	371.0	390.0
	LOCK AND DAM NO. 11	(CANCELLED)		
1969	DARDANELLE LOCK AND DAM NO. 10 (1)	257.8 DC	338.0	354.0
1969	LOCK AND DAM NO. 9	224.9 DC	284.0	299.0
1969	LOCK AND DAM NO. 8	82.2 DC	241.0	249.0
1969	LOCK AND DAM NO. 7	172.5 DC	206.0	217.0
1968	DAM NO. 6, TERRY LOCK AND DAM	134.6 DC	231.0	243.0
1968	LOCK AND DAM NO. 5	128.0 DC	213.0	224.0
1968	LOCK AND DAM NO. 4	(2) 87.7 DC	196.0	210.0
1968	LOCK AND DAM NO. 3	(2) 72.3 DC	182.0	192.0
1969	DAM NO. 2	621. 40.5 DC	162.0	APPROACH 0
1968	LOCK NO. 2	(3) 13.4	162.0	167.0
1968	LOCK AND DAM NO. 1	(3) 10.4	141.0	APPROACH 0

(1) MULTIPLE PURPOSE.
(2) 1963 SURVEY.
(3) ALONG ARKANSAS POST CANAL ROUTE.

LEGEND
- Canalization approved
- Navigation lock & dam
- Navigation-power reservoir
- Reservoir included in multiple-purpose plan
- Reservoir in operation (not included in multiple purpose plan)
- Reservoir approved (not included in multiple purpose plan)

PREPARED BY U.S. CORPS OF ENGINEERS

WATER QUALITY STUDY
OZARK WELL FIELD
ARKANSAS RIVER BASIN - ARKANSAS

RIVER BASIN DEVELOPMENT
POSTCONSTRUCTION CONDITIONS

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration

IV. DISCUSSION

Factors Affecting Water Quality

Surface Water

Mineral pollution is the most important factor restricting use of Arkansas River water for municipal supplies. An average of 20,000 tons[2/] per day of salt (NaCl) enter the Arkansas River upstream from Van Buren, Arkansas. Approximately 53 percent[2/] of the total load comes from well defined natural brine emissions, while the remaining portion comes from man-made and scattered minor natural sources.

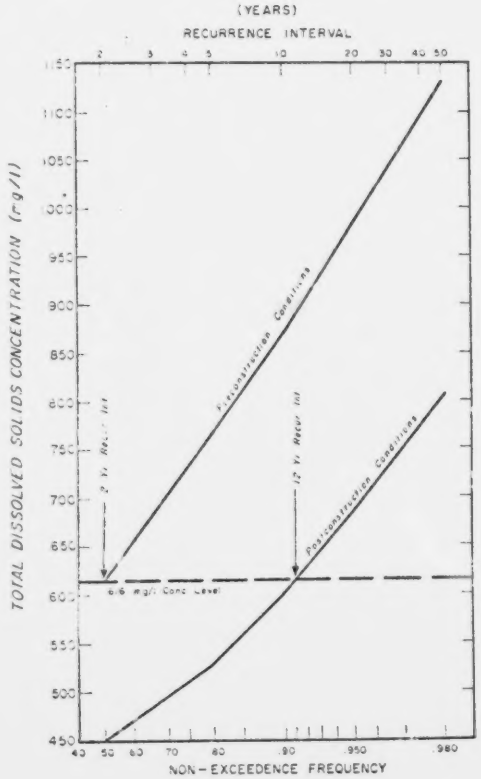
Although large quantities of chemical pollutants are discharged to the river, the volume of flow below Van Buren, Arkansas is normally large enough to prevent high concentrations. However, prior to construction of upstream reservoirs, extreme variations in flow occurred causing wide fluctuations in mineral concentrations. Very high concentrations occurred during low flow periods. This fluctuation in quality made the river an undesirable municipal water supply source. When the Arkansas River Multiple-Purpose Plan is completed, flow rates will be equalized causing water quality fluctuations to be minimized.

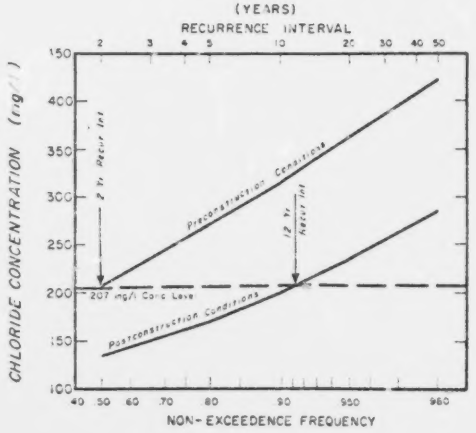
A comparison of preconstruction and postconstruction average annual mineral concentration levels (figure IV-1) illustrates the extent of the reduction in concentration levels that is expected from flow regulation. For example, under preconstruction conditions river water average annual chloride and total dissolved solids concentrations of 207 mg/l and 616 mg/l, respectively, would be equaled or exceeded once every two years at Ozark. Under postconstruction conditions the recurrence interval for these average annual concentration levels will be once every twelve years.

Ground Water

The U. S. Geological Survey found that during the period from March 1965 through February 1966, the city of Ozark well field combined cone of depression extended to the Arkansas River causing movement of river water through the alluvium to the wells. During 1965, about 52 percent of the 121.3 million gallons of water pumped from city wells was induced from the river.[1/]

Since city wells are located near the river, increases in the pumping rate produce definite increases in the piezometric gradient from the river to the well, while the gradient to the well from the





WATER QUALITY STUDY
OZARK WELL FIELD
ARKANSAS RIVER BASIN— ARKANSAS

RIVER WATER CHLORIDE AND TOTAL DISSOLVED SOLIDS AVERAGE ANNUAL CONCENTRATIONS AT OZARK

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTHWEST REGION — JAN. 10, 1967 — DALLAS, TEXAS

FIGURE IV-1

opposite direction, which carries recharge from rainfall, is affected very little.[1/] Therefore, as the city of Ozark increases in population and water demands grow, even with natural uncontrolled river conditions, the volume of river water induced into the well field aquifer will increase. Pumpage from the Ozark well field is expected to increase to 146 million gallons per year in 1970, (see figure B-1).

When the Ozark Lock and Dam is placed in operation at river mile 308.9, which is immediately downstream from the Ozark well field alluvial area, the water surface in the pool behind the dam will be raised to an elevation of 372 feet above m.s.l. which is about 29 feet higher than the 1965 average river stage.[1/] Impoundment at this elevation will cause river water to percolate through the alluvial area. At the same time recharge of the aquifer by rainfall will be reduced from approximately 3.0 inches to 0.7 inches per year over the alluvial area.[1/] The U. S. Geological Survey has projected that, under postconstruction conditions with the estimated 1970 pumping rate, an average of 93 percent of the water pumped by city wells will be induced from the river.

Water Quality

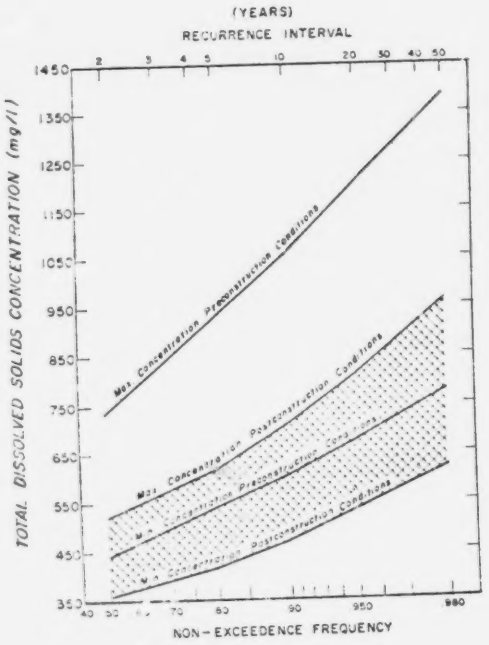
Surface Water

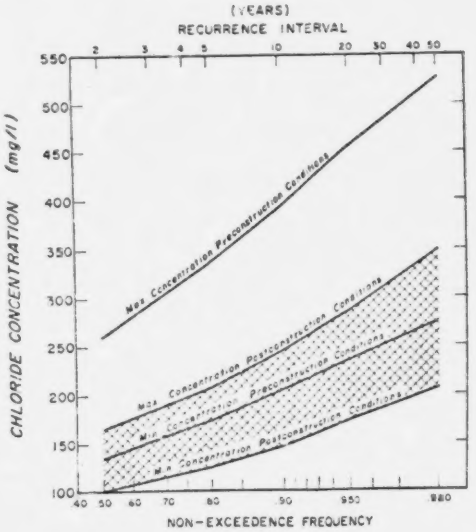
A statistical evaluation of historical data indicates that, under preconstruction conditions, the average annual concentrations of chlorides and total dissolved solids in river water at Ozark would exceed concentration levels of 207 mg/l and 616 mg/l, respectively, 50 percent of the time (table A-1). Under postconstruction conditions, these average annual concentration levels will be reduced to 137 mg/l chlorides and 450 mg/l total dissolved solids (table A-2). Tables A-1 and A-2 show probable average annual preconstruction and postconstruction concentrations as well as a sequence of average concentrations for 30-day periods.

Figure IV-2 graphically presents the expected ranges of preconstruction and postconstruction mineral concentrations in the river water. It can be seen from this figure that the range of concentration fluctuations will be substantially reduced under postconstruction conditions.

Ground Water

Since a large portion of the water pumped from city wells will be river water that has percolated into the aquifer, the variations in well water quality will be directly affected by the





WATER QUALITY STUDY
OZARK WELL FIELD
ARKANSAS RIVER BASIN - ARKANSAS

RIVER WATER CHLORIDE AND TOTAL DISSOLVED SOLIDS CONCENTRATION RANGES

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration

sequence of quality changes in the river water.[1/] A reduction of the range of mineral concentration fluctuations in the river water will likewise be reflected in a similar reduction in the well water. Figure IV-3 shows preconstruction and postconstruction concentration ranges of chlorides and total dissolved solids expected in the Ozark water supply under the assumed 1970 pumping conditions. A definite reduction in the range of quality fluctuations is apparent. Tables C-1 and C-2 show projected average concentrations for 30-day periods under preconstruction and postconstruction conditions for each individual well, and for the composite supply. These data were developed by the U. S. Geological Survey with an analog model of the well field aquifer.[1/] It should be noted that all quality comparisons in this report are made using the composite supply quality estimates.

Water Quality Criteria

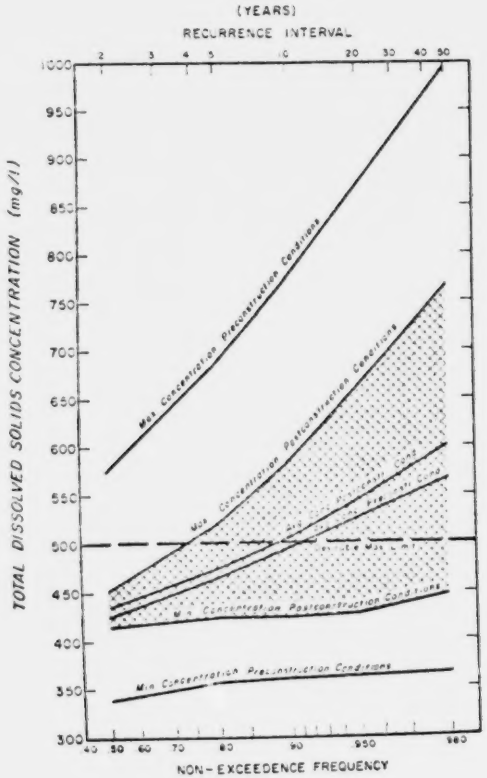
General

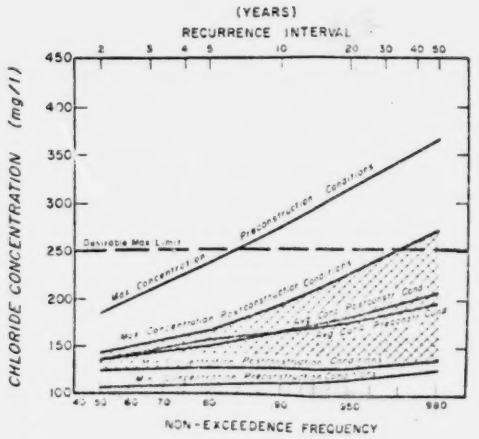
Even though the quality of water required for domestic supplies is closely regulated, many industrial processes often cannot use water provided in domestic systems without further treatment. It would be impossible to establish a single set of criteria to include quality requirements for all industrial processes; such quality requirements differ far too much to allow simplification. The discussion in this section will be restricted to domestic water supply quality criteria since industries are generally willing to accept, for most processes, water provided for domestic use. Industry normally accepts responsibility for any further treatment required. One characteristic, however, is of primary importance for all industries, namely, that the concentrations of the various constituents of the water remain relatively constant.

Only criteria for chlorides and total dissolved solids will be discussed. An examination of chemical analyses of river and well water shows that these constituents have frequently reached very high concentrations. Other constituents do not reach concentrations that would be considered a threat to the quality of a municipal water supply.

Chlorides

Chlorides in drinking water are generally not harmful to human beings, although they may be injurious to some people suffering from diseases of the heart or kidneys. Restrictions on chloride concentrations in drinking water are generally based on palatability requirements rather than on health.


(YEARS)
RECURRENCE INTERVAL
2 3 4 5 10 20 30 40 50
1000 950 900 850 800 750 700 650 600 550 500 450 400 350 300
TOTAL DISSOLVED SOLIDS CONCENTRATION (mg/l)
Max Concentration Preconstruction Conditions
Max Concentration Postconstruction Conditions
Min Concentration Postconstruction Conditions
Min Concentration Preconstruction Conditions
40 50 60 70 80 90 950 980
NON-EXCEEDENCE FREQUENCY


(YEARS)
RECURRENCE INTERVAL
2 3 4 5 10 20 30 40 50
450 400 350 300 250 200 150 100
CHLORIDE CONCENTRATION (mg/l)
Desirable Max Limit
Preconstruction Conditions
Max Concentration
Max Concentration Postconstruction Conditions
40 50 60 70 80 90 250 980
NON-EXCEEDENCE FREQUENCY

Measurement of taste intensity can be performed in the same general manner as that of odor intensity. The threshold concentration of the offending substances varies in individuals. Sodium chloride is detected in concentrations from 300 to 900 mg/l of NaCl, and becomes objectionable enough to curtail water comsumption when its concentration reaches 1,000 to 1,500 mg/l.[3/] For average individuals, the taste threshold is about 400 mg/l.[4/]

A Kettering laboratory survey,[5/] shows that laxative effects of chloride are generally apparent only when an individual has been accustomed to a lower concentration of the salt. Within a few days, an individual adjusts physiologically to a higher level of salt intake.

The World Health Organization International Standards of 1958 set a chloride concentration permissible limit of 200 mg/l, and an excessive limit of 600 mg/l.[6/] For the WHO European Drinking Water Standards, the recommended limit is 350 mg/l,[7/] and no tolerance limit is specified.

In the Public Health Service Drinking Water Standards-1962,[8/] the recommended upper limit for the chloride concentration in a water supply is 250 mg/l, where, in the judgement of the reporting agency and the certifying authority, other more suitable supplies are or can be made available.

No limitations have yet been established on the quantity of chlorides an individual can safely consume.

Total Dissolved Solids

Restrictions on dissolved solids concentrations in drinking water are generally based on palatability requirements.

In the Public Health Service Drinking Water Standards-1962,[8/] the recommended upper limit for the total dissolved solids concentration in a water supply is 500 mg/l, where, in the judgement of the reporting agency and the certifying authority, other more suitable supplies are or can be made available.

The 1958 International Standards for Drinking Water[6/] set the permissible total dissolved solids limit at 500 mg/l and the excessive limit at 1,500 mg/l but no maximum allowable limit is given. The 1961 WHO European Standards[7/] do not include limits for total dissolved solids.

No limitations have yet been established on the quantity of dissolved solids an individual can safely consume. Many communities in the United States and in foreign countries use water having a concentration of dissolved solids in excess of 500 mg/l.

Synthesis of Quality Data

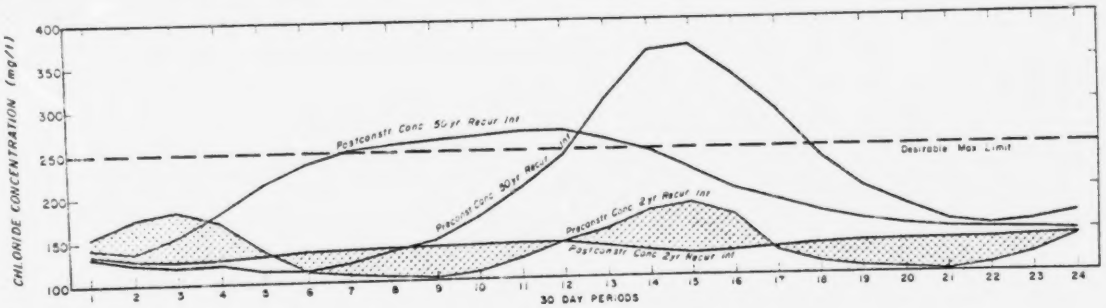
From the previous discussion on water quality criteria it can be seen that high concentrations of chlorides and total dissolved solids in a water supply are not considered detrimental to health but may cause a detectable taste that would be disagreeable or unpalatable to some people.

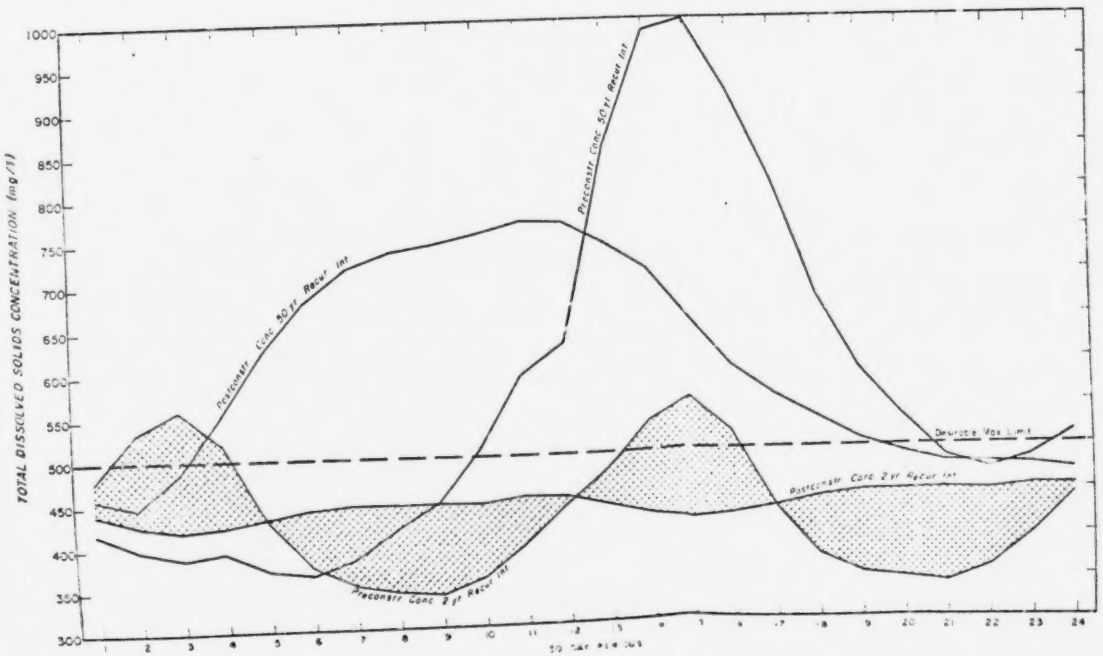
Since the ability of people to detect tastes varies, defining absolute maximum allowable concentrations of chlorides and total dissolved solids is not practicable; a degree of flexibility is necessary. Levels of acceptability can be established, however. In the United States, concentration levels recommended in the U. S. Public Health Service Drinking Water Standards-1962 are generally accepted as maximum desirable limits, yet exceeding these limits is not normally considered detrimental, but less desirable.

Quality data in figure IV-4 shows that under the assumed 1970 pumping conditions, chloride and total dissolved solids concentrations in the Ozark city water supply will at times exceed desirable maximum limits under both preconstruction and postconstruction conditions. However, figure IV-3 shows that maximum concentration levels are much lower and the range of quality fluctuations is significantly reduced under postconstruction conditions. For example, the chloride concentration range under preconstruction conditions for a 2-year recurrence interval, is 102 to 185 mg/l, or a fluctuation of 83 mg/l while under postconstruction conditions, the range is 126 to 141 mg/l, or a fluctuation of 15 mg/l. Peak preconstruction and postconstruction values differ by 44 mg/l.

Table IV-1 shows that for a 50-year recurrence interval, the maximum chloride concentration under postconstruction conditions will exceed the 250 mg/l concentration level established by the U. S. Public Health Service by 22 mg/l. However, for this event the postconstruction concentrations will be about 96 mg/l less than the maximum preconstruction concentrations. The duration of exceedence for the 50-year recurrence interval will be somewhat longer under postconstruction conditions than under preconstruction conditions (5 periods vs. 7 periods). The increase in duration is, however, offset by a reduction in the concentration of chlorides.

Table IV-1 also shows that for all the recurrence intervals considered, the concentration of total dissolved solids under preconstruction conditions exceeds the desirable limit of 500 mg/l established by the U. S. Public Health Service. These concentrations range from a minimum of 340 mg/l to a maximum of 996 mg/l. Under postconstruction conditions the desirable limit would be exceeded for all recurrence intervals except the 2-year interval,


CHLORIDE CONCENTRATION (mg/l)
400
350
300
250
200
150
100
Postconstr Conc 50 yr Recur Int
Preconstr Conc 50 yr Recur Int
Desirable Max Limit
Preconstr Conc 2 yr Recur Int
Postconstr Conc 2 yr Recur Int
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
30 DAY PERIODS



WATER QUALITY STUDY
OZARK WELL FIELD
ARKANSAS RIVER BASIN - ARKANSAS

WELL WATER CHLORIDE AND TOTAL DISSOLVED SOLIDS CONCENTRATIONS
(2 YEAR & 50 YEAR RECURRENCE INTERVALS)

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTH CENTRAL REGION Jun 10, 1967 DALLAS, TEXAS

FIGURE IV-4

Table IV-1

QUALITY ESTIMATES
CITY OF OZARK WELL WATER

Preconstruction and Postconstruction Comparison

Non-Exceedence Frequency (%)	50	80	90	95	98
Recurrence Interval (Years)	2	5	10	20	50
CHLORIDE					
Concentration Range[1] (mg/1)					
Preconstruction conditions	102-185	109-239	111-276	112-316	114-368
Postconstruction conditions	126-141	129-169	129-196	129-228	138-272
Period[2] concentration exceeds desirable limits					
Preconstruction conditions	0	0	3	5	5
Postconstruction conditions	0	0	0	0	7
TOTAL DISSOLVED SOLIDS					
Concentration Range[1]					
Preconstruction conditions	340-557	358-687	362-776	364-872	366-996
Postconstruction conditions	419-452	425-521	425-585	426-660	446-766
Period[2] concentration exceeds desirable limits					
Preconstruction conditions	6	6	7	9	12
Postconstruction conditions	0	6	12	15	16

1/ Range for 24, 30-day periods in response to a year of river water quality at various non-exceedence frequencies. (See Appendix C.)

2/ Number of 30-day periods, from a series of 24 periods, when average concentrations exceed desirable limits (250 mg/1 Cl, and 500 mg/1 TDS)

Source: Tables C-1 and C-2.

with concentrations ranging from a minimum of 419 mg/l to a maximum of 766 mg/l. The increase in duration that will occur under postconstruction conditions will be offset by a decrease in the total dissolved solids concentrations.

Although chloride and total dissolved solids concentrations would not always be within the desirable limits recommended by the U. S. Public Health Service, the resultant postconstruction concentrations would be relatively constant and variations in taste would be difficult to detect. Variations in taste are easier to detect when mineral concentrations fluctuate widely and especially where they occasionally reach such high values as they do under preconstruction conditions.

To complete the analyses, it should be noted that postconstruction minimum concentration levels, figure IV-3, will be raised above levels that would occur under preconstruction conditions. This results in slightly higher annual average concentrations. Consequently, the total quantity of salts pumped from city wells over a long period of time will be increased above preconstruction quantities. This is of little significance, however, since the distribution of the salt load throughout this period is such that the resultant overall concentration range is more favorable.

This study shows that, after completion of the Arkansas River Multiple-Purpose Plan, the quality of water pumped from the Ozark well field aquifer will be altered. However, the resultant water quality will allow the continued use of the well field as an acceptable municipal water supply. In fact, a comparison of the quality of water that would be supplied under preconstruction and postconstruction conditions, at projected 1970 pumping rates, indicates that a better quality water would be provided under postconstruction conditions. Therefore, it is concluded that the changes in the quality of the Ozark well water supply that may be attributed to the multiple-purpose plan will not preclude its further use for municipal water supply purposes.

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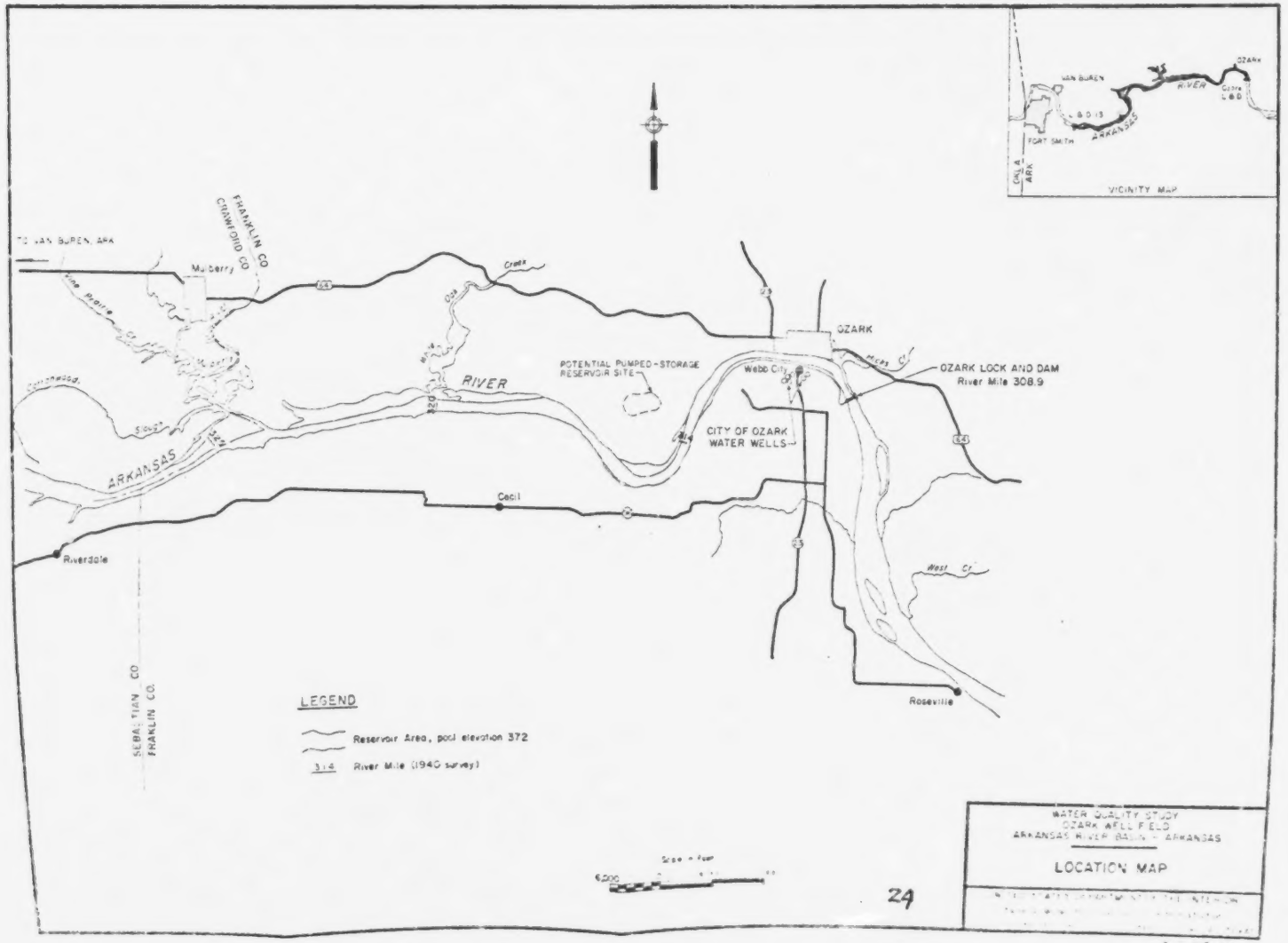

TO VAN BUREN, ARK
FRANKLIN CO
CRAWFORD CO
Mulberry
Creek
Fine Prairie Cr
Mulberry R
Cove Creek
ARKANSAS RIVER
POTENTIAL PUMPED-STORAGE RESERVOIR SITE
OZARK
Webb City
West Cr
OZARK LOCK AND DAM
River Mile 308.9
CITY OF OZARK WATER WELLS
Cecil
Riverdale
Roseville
SEBASTIAN CO
FRANKLIN CO.
LEGEND
Reservoir Area, pool elevation 372
River Mile (1940 survey)
Scale of Feet
24
WATER QUALITY STUDY
OZARK AFLL FIELD
ARKANSAS RIVER BASIN - ARKANSAS
LOCATION MAP
VICINITY MAP
VAN BUREN
FORT SMITH
ARKANSAS
RIVER
OZARK
L & D 13
L & D
CAL & ARK

APPENDIX A

PROCEDURE USED FOR DERIVATION OF RIVER WATER QUALITY ESTIMATES

Preconstruction Estimates

Quality data at the Ozark Reservoir site was calculated utilizing the following techniques:

1. U.S. Geological Survey flow records from 1928 to 1960 and records of chloride concentrations in river water from October 1945 through September 1962 were utilized. These records were chosen because it was felt that they reflect actual conditions prevailing prior to closure of the major structures included in the Arkansas River Multiple-Purpose Plan. (See figure III-2.) The records are of sufficient length to produce statistically significant results in calculations used to predict future events.

   The flow and chloride concentration data were measured at Van Buren, Arkansas and assumed to be the same at Ozark, some 45 miles downstream.

2. Annual mean flows were calculated and plotted using log-probability coordinates.

3. Annual mean flows for exceedence frequencies of 50, 80, 90, 95, and 98 percent were taken from the curve described in Number 2 above.

4. Median flows for 30-day periods were calculated and the annual mean flows were adjusted in accordance with the median to obtain a 12-period sequence of 30-day flows. Other sequences (7-day, 14-day, 60-day, and 91-day) were also calculated. However, the 30-day sequence was selected by the U.S. Geological Survey as the most appropriate for use in their analog model of the well field aquifer. 1/

5. Logarithms of flows and chloride concentrations, observed at Van Buren, were correlated and resulted in the following equation:

$$C = 9550\ Q^{-0.381}$$

   Where C is the chloride concentration in mg/l, Q is the flow in cfs, and 9550 and -0.381 are regression coefficients.

6. For each 30-day flow, a corresponding chloride concentration from the curve in Number 5 above was obtained.

7. Total dissolved solids concentrations were then obtained from the relationship:

$$TDS = 2.38137 (Cl + 52)$$

Where TDS is the total dissolved solids concentration in mg/l, and Cl is the chloride concentration in mg/l.

This relationship was determined through intensive sampling at Van Buren during the years 1961 and 1962 as part of the Arkansas-Red Rivers project. 2/

Postconstruction Estimates

Quality data for Ozark Reservoir water was calculated utilizing the following techniques:

1. A chloride routing study prepared by the Tulsa District, Corps of Engineers for a previous study was used to estimate chloride concentrations expected to occur at Van Buren, Arkansas. In the study, river basin historic flows were routed through impoundments shown on figure III-3 to Van Buren. These modified flows, together with a correlation of historic flows and chloride concentrations, were used to calculate the modified chloride concentrations. Historic flow records for 19 climatic years (1938 to 1957) and river water chloride concentration records from 1945 to 1962 were used in the routing study. It was felt that the records used are of sufficient length to produce statistically significant results in calculations used to predict future events.

   Water quality in the Ozark Reservoir was assumed to be the same as the quality at Van Buren and was assumed to be uniform in quality since thermal stratification in this type reservoir would normally be negligible.

2. Annual mean chloride concentrations were calculated, and plotted on log-probability coordinates.

3. Annual mean chloride concentrations for non-exceedence frequencies of 50, 80, 90, 95, and 98 percent were taken from the curve described in Number 2 above.

4. Median chloride concentrations for 30-day periods were calculated and the annual mean concentrations were prorated in accordance with the median to obtain a 12-period

sequence of 30-day average chloride concentrations. Other sequences (7-day, 14-day, 60-day, and 91-day) were also calculated. However, the 30-day sequence was selected by the U.S. Geological Survey as the most appropriate for use in their analog model of the well field aquifer. 1/

5. Total dissolved solids concentrations were then obtained from the relationship:

$$TDS = 2.38137 (Cl + 52)$$

Where TDS is the total dissolved solids concentration in mg/l, and Cl is the chloride concentration in mg/l.

This relationship was determined through intensive sampling at Van Buren during the years 1961 and 1962 as part of the Arkansas-Red River project. 2/

It is believed that the quality data developed is comparable to the preconstruction data and forms the basis for a valid comparison of resultant water quality, before and after construction of the Arkansas River Multiple-Purpose Plan. Tables A-1 and A-2 contain the river water quality data developed.

Table A-1

QUALITY ESTIMATES
ARKANSAS RIVER WATER
AT OZARK[1/]

Preconstruction Conditions

30-Day[2/] Period	50 Percent Non-Exceedence Frequency or 2-year Recurrence Interval		80 Percent Non-Exceedence Frequency or 5-year Recurrence Interval		90 Percent Non-Exceedence Frequency or 10-year Recurrence Interval		95 Percent Non-Exceedence Frequency or 20-year Recurrence Interval		98 Percent Non-Exceedence Frequency or 50-year Recurrence Interval	
	Chloride (mg/l)	TDS (mg/l)	Chloride (mg/l)	TDS (mg/l)	Chloride (mg/l)	TDS (mg/l)	Chloride (mg/l)	TDS (mg/l)	Chloride (mg/l)	TDS (mg/l)
1	167	522	220	648	256	734	293	822	341	936
2	133	441	175	541	203	607	232	676	273	774
3	143	464	186	567	217	641	250	719	292	819
4	200	600	259	741	300	838	342	938	405	1,088
5	242	700	315	874	369	1,003	425	1,136	495	1,303
6	230	672	298	834	350	957	400	1,077	470	1,243
7	255	731	331	912	386	1,043	448	1,191	520	1,362
8	252	724	328	905	384	1,038	446	1,186	515	1,350
9	260	743	338	929	391	1,055	455	1,208	528	1,381
10	224	657	292	819	340	934	390	1,053	460	1,219
11	193	584	252	724	295	826	338	929	395	1,065
12	182	557	237	688	275	779	312	867	369	1,003
Average	207	616	271	770	314	871	361	984	422	1,129

1/ For this study, water quality at Ozark was assumed equal to quality at the Van Buren gage.
2/ First period begins on April 1.

Table A-2

QUALITY ESTIMATES
ARKANSAS RIVER WATER
AT OZARK[1/]

Postconstruction Conditions

30-Day[2/] Period	50 Percent Non-Exceedence Frequency or 2-year Recurrence Interval		80 Percent Non-Exceedence Frequency or 5-year Recurrence Interval		90 Percent Non-Exceedence Frequency or 10-year Recurrence Interval		95 Percent Non-Exceedence Frequency or 20-year Recurrence Interval		98 Percent Non-Exceedence Frequency or 50-year Recurrence Interval	
	Chloride (mg/l)	TDS (mg/l)	Chloride (mg/l)	TDS (mg/l)	Chloride (mg/l)	TDS (mg/l)	Chloride (mg/l)	TDS (mg/l)	Chloride (mg/l)	TDS (mg/l)
1	128	429	159	503	187	569	220	643	267	760
2	127	426	157	498	185	564	217	641	263	750
3	159	503	198	595	233	679	273	774	331	912
4	164	514	203	607	239	693	281	793	341	936
5	142	462	176	543	207	617	243	703	294	824
6	143	464	177	545	208	619	245	707	297	831
7	168	524	209	622	246	710	288	810	350	957
8	141	460	175	541	205	612	241	698	293	822
9	143	464	177	545	209	622	246	710	298	834
10	121	412	150	481	177	545	208	619	252	724
11	100	362	124	419	146	472	171	531	208	619
12	108	381	135	445	158	500	187	569	226	662
Average	137	450	170	529	200	600	235	684	285	803

1/ For this study, water quality at Ozark was assumed equal to quality at the Van Buren gage.
2/ First period begins on April 1.

APPENDIX B

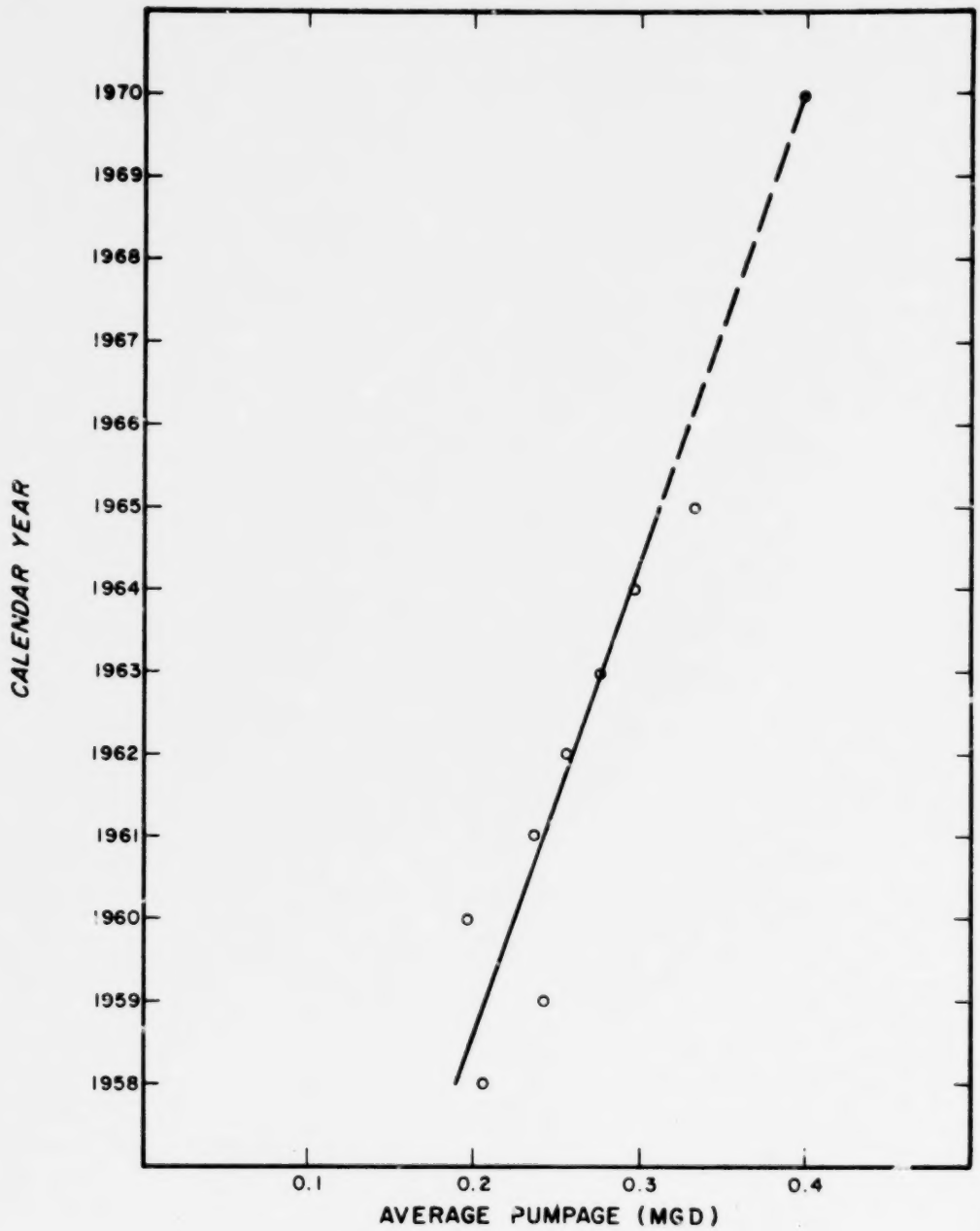
PROCEDURE USED FOR DERIVATION OF THE CITY OF OZARK 1970 MUNICIPAL WATER REQUIREMENTS

The following technique was used to estimate the quantity of water needed to satisfy Ozark's municipal supply demands during the year 1970.

1. Historic demands for the calendar years 1958 to 1965 were plotted on an arithmetic coordinate grid. A curve was drawn through the points and extended to the year 1970. (See figure B-1.)

2. Average 30-day pumpage was calculated using 1965-66 demands and used to prorate the projected 1970 demand to obtain a sequence of 30-day pumpage. Other sequences (7-day, 14-day, 60-day, and 91-day) were also calculated. However, the sequence of 30-day pumpage was selected by the U. S. Geological Survey as the most appropriate for use in their analog model of the well field aquifer.[1/]

Table B-1 shows the sequence of 30-day pumpage projected for 1970 and historical records of pumpage for calendar years 1961-65.



WATER QUALITY STUDY
OZARK WELL FIELD
ARKANSAS RIVER BASIN — ARKANSAS

PUMPAGE PROJECTIONS

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTH CENTRAL REGION Jan 10, 1967 DALLAS, TEXAS

FIGURE B-1

Table B-1

Pumpage From
City of Ozark Well Field

Projected Pumpage During 1970

30-day period 1/	Pumpage (million gallons)
1	8.40
2	9.75
3	12.57
4	19.68
5	24.78
6	16.68
7	12.00
8	9.36
9	7.89
10	7.14
11	7.50
12	8.25
Total (360 days)	144.00

Historical Record of Pumpage 1960-1965

Month	Pumpage (million gallons) 1961	1962	1963	1964	1965
Jan.	3.0	3.3	3.5	3.9	4.2
Feb.	4.0	4.3	4.6	4.8	5.8
Mar.	4.6	4.9	5.3	5.1	7.0
Apr.	4.7	5.1	5.5	5.8	6.7
May	5.3	5.8	6.2	6.6	7.5
June	7.0	7.6	8.2	8.9	9.7
July	10.6	11.5	12.4	12.8	15.4
Aug.	11.2	12.1	13.1	14.3	15.6
Sept.	10.8	11.7	12.6	14.5	14.2
Oct.	10.4	11.3	12.2	13.6	14.1
Nov.	8.6	9.3	10.1	11.1	11.9
Dec.	5.9	6.4	6.9	6.6	9.2
TOTAL	86.1	93.3	100.7	108.2	121.3

1/ First period beings April 1.

APPENDIX C

OZARK WELL WATER QUALITY ESTIMATES

Ozark well water quality is directly associated with the interrelationship of the aquifer hydrology and the sequence of quality changes in river water. This interrelationship was defined by the U. S. Geological Survey through construction of an electrical analog model of the study area.[1/]

River water quality and 1970 pumpage projections (see Appendixes A and B) were used by the U. S. Geological Survey in the analog model to compute well water quality. To calculate well water quality related to a 50 percent non-exceedence frequency river water quality, the U. S. Geological Survey assumed that the river quality for a 50 percent non-exceedence frequency would continue at that quality for a series of 30-day periods. It was assumed that river quality for 80, 90, 95, and 98 percent non-exceedence frequencies would exist for only twelve 30-day periods, and would be preceded and followed by a series of 30-day periods of river water quality having a 50 percent non-exceedence frequency.

Tables C-1 and C-2 contain well water quality data developed by the U. S. Geological Survey. The 24 periods of data included are of sufficient length to reflect the extremes of quality changes caused by movement of river water into the well field aquifer. To determine the quality of a composite supply, the percentage of the total pumpage each well delivers was assumed to be the same as that observed in 1965.[1/] It should be recognized that variations in the pumping schedule could produce numerous other combinations for creation of a composite supply. However, the same combination was used for both preconstruction and postconstruction calculations. Therefore, the composite quality estimates can be compared to predict changes that will occur when the Arkansas River Multiple-Purpose Plan is completed.

QUALITY ESTIMATES - OZARK WELL WATER (Preconstruction Conditions)

50 Percent Non-Exceedence Frequency or 2-Year Recurrence Interval (Concentrations in mg/l)

30-day period 1/	Well No. 1		Well No. 2		Well No. 3		Well No. 4		Well No. 5		Well No. 6		Composite	
	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids
1	233	680	119	384	181	545	175	530	30	150	70	257	155	479
2	226	664	149	461	190	569	209	620	30	150	92	313	176	534
3	213	631	161	494	195	583	225	661	30	150	104	346	185	557
4	197	594	119	385	188	566	218	641	30	150	79	278	170	518
5	185	565	75	270	170	519	169	515	30	150	48	197	136	429
6	173	535	65	243	155	481	131	416	30	150	40	177	114	374
7	174	534	63	237	148	463	113	370	30	150	38	171	106	351
8	184	558	58	225	147	462	108	357	30	150	33	159	104	346
9	189	569	58	225	148	463	101	339	30	150	33	157	102	340
10	199	592	66	247	154	478	108	358	30	150	38	171	109	358
11	212	627	88	302	163	500	125	403	30	150	51	206	123	396
12	231	674	106	349	173	525	150	468	30	150	62	235	142	443
13	233	680	119	384	181	545	175	530	30	150	70	257	155	479
14	226	664	149	461	190	569	209	620	30	150	92	313	176	534
15	213	631	161	494	195	583	225	661	30	150	104	346	185	557
16	197	594	119	385	188	566	218	641	30	150	79	278	170	518
17	185	565	75	270	170	519	169	515	30	150	48	197	136	429
18	173	535	65	243	155	481	131	416	30	150	40	177	114	374
19	174	534	63	237	148	463	113	370	30	150	38	171	106	351
20	184	558	58	225	147	462	108	357	30	150	33	159	104	346
21	189	569	58	225	148	463	101	339	30	150	33	157	102	340
22	199	592	66	247	154	478	108	358	30	150	38	171	109	358
23	212	627	88	302	163	500	125	403	30	150	51	206	123	396
24	231	674	106	349	173	525	150	468	30	150	62	235	142	443

Source: U.S. Geological Survey.

1/ First period begins on April 1.

Table C-1 (Continued)

QUALITY ESTIMATES - OZARK WELL WATER (Preconstruction Conditions)

80 Percent Non-Exceedence Frequency or 5-Year Recurrence Interval (Concentrations in mg/1)

10-day 1/ period	Well No. 1		Well No. 2		Well No. 3		Well No. 4		Well No. 5		Well No. 6		Composite	
	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids
1	233	680	101	337	177	535	161	495	30	150	59	227	146	454
2	226	664	108	355	181	546	170	539	30	150	65	241	154	475
3	216	639	122	393	182	550	184	554	30	150	77	273	159	487
4	210	624	96	323	180	543	179	539	30	150	59	227	149	462
5	200	598	64	240	168	512	145	451	30	150	37	168	125	400
6	191	574	59	226	160	492	120	387	30	150	33	153	111	364
7	199	592	60	230	159	490	111	363	30	150	32	158	109	358
8	217	636	60	229	165	503	113	368	30	150	31	154	113	367
9	229	664	63	237	170	515	113	367	30	150	32	156	116	374
10	244	700	75	267	181	543	126	402	30	150	38	173	127	403
11	262	747	100	331	195	576	151	463	30	150	52	209	147	452
12	287	809	124	392	210	614	184	547	30	150	65	243	171	513
13	294	825	163	492	226	654	229	662	30	150	88	301	200	587
14	287	807	223	645	244	700	281	795	30	150	127	401	235	677
15	266	758	231	666	257	732	286	806	30	150	141	437	239	687
16	237	689	168	507	245	703	283	798	30	150	109	353	220	639
17	213	632	106	349	218	636	242	694	30	150	68	250	183	545
18	204	611	89	304	194	575	185	549	30	150	57	219	151	465
19	200	598	83	288	180	540	154	472	30	150	51	205	135	424
20	205	611	74	266	173	524	141	439	30	150	43	186	127	404
21	208	614	71	258	170	517	125	400	30	150	40	178	120	386
22	214	630	77	273	173	524	127	404	30	150	44	188	123	394
23	225	658	96	323	179	538	138	435	30	150	58	223	135	424
24	241	698	112	363	186	556	159	489	30	150	68	249	150	464

Source: U.S. Geological Survey.

1/ First period begins on April 1.

QUALITY ESTIMATES - OZARK WELL WATER (Preconstruction Conditions)

90 Percent Non-Exceedence Frequency or 10-Year Recurrence Interval (Concentrations in mg/1)

30-day 1/ period	Well No. 1		Well No. 2		Well No. 3		Well No. 4		Well No. 5		Well No. 6		Composite	
	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids
1	233	680	92	313	175	530	155	478	30	150	53	211	141	441
2	226	664	88	304	177	534	164	500	30	150	51	207	143	446
3	218	644	105	347	176	534	162	495	30	150	64	239	145	451
4	218	643	84	293	177	535	161	492	30	150	50	203	140	438
5	206	612	58	224	168	511	134	422	30	150	31	154	120	386
6	203	602	55	216	164	501	115	374	30	150	30	150	111	362
7	216	632	59	225	167	508	110	360	30	150	30	150	112	363
8	241	691	61	229	177	532	116	374	30	150	30	150	119	381
9	257	731	66	244	185	551	120	384	30	150	31	155	125	396
10	276	777	81	281	200	588	139	431	30	150	39	173	141	434
11	299	835	110	355	218	631	169	507	30	150	54	213	164	494
12	328	905	138	425	237	678	208	606	30	150	68	250	192	564
13	333	919	193	565	258	731	268	757	30	150	99	330	231	662
14	325	899	274	770	282	791	323	894	30	150	151	460	272	765
15	301	841	279	785	299	833	328	906	30	150	166	499	276	776
16	264	753	202	590	283	795	323	894	30	150	129	404	252	717
17	232	677	127	401	251	714	293	818	30	150	83	286	215	624
18	219	646	105	345	220	639	222	639	30	150	68	248	176	525
19	216	639	96	321	201	592	182	541	30	150	61	229	154	472
20	219	644	84	291	190	566	162	492	30	150	50	203	142	442
21	219	643	79	278	185	552	141	439	30	150	46	191	132	415
22	224	654	83	289	186	554	138	432	30	150	49	199	133	417
23	233	678	101	336	189	563	147	455	30	150	62	233	142	442
24	248	714	115	372	194	577	165	503	30	150	72	258	156	478

Source: U.S. Geological Survey

1/ First period begins on April 1.

Table C-1 (Continued)

QUALITY ESTIMATES - OZARK WELL WATER (Preconstruction Conditions)

95 Percent Non-Exceedence Frequency or 20-Year Recurrence Interval (Concentrations in mg/l)

30-day 1/ period	Well No. 1		Well No. 2		Well No. 3		Well No. 4		Well No. 5		Well No. 6		Composite	
	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids
1	231	673	86	296	173	526	150	466	30	150	49	200	137	430
2	223	656	74	265	173	526	152	471	30	150	42	182	134	424
3	212	626	91	309	172	522	145	450	30	150	54	213	133	420
4	218	641	75	268	175	528	147	455	30	150	42	183	131	415
5	214	629	53	211	169	513	125	398	30	150	30	150	117	377
6	216	632	52	209	168	511	112	364	30	150	30	150	112	364
7	234	675	58	222	176	528	111	360	30	150	30	150	116	372
8	265	742	62	232	190	562	120	384	30	150	30	150	127	393
9	286	800	70	251	201	589	128	403	30	150	31	153	136	420
10	310	857	87	295	220	634	151	461	30	150	39	174	154	466
11	337	925	119	377	242	688	188	551	30	150	55	215	182	535
12	371	1,009	152	459	265	744	233	665	30	150	71	256	214	617
13	379	1,027	227	646	292	813	310	856	30	150	111	358	264	742
14	369	1,004	329	904	323	889	367	998	30	150	175	519	311	860
15	340	934	331	910	345	944	373	1,014	30	150	192	561	316	872
16	293	822	237	677	326	897	367	999	30	150	151	456	288	802
17	252	726	149	455	286	799	347	951	30	150	98	322	250	708
18	235	684	121	385	249	708	262	736	30	150	80	277	202	588
19	233	680	109	353	224	647	212	613	30	150	70	253	175	523
20	233	677	94	315	209	610	185	547	30	150	58	221	158	481
21	231	671	87	297	201	590	157	479	30	150	51	204	144	445
22	234	678	90	305	199	586	150	462	30	150	53	210	142	441
23	242	698	107	349	200	590	156	477	30	150	67	245	150	461
24	255	732	120	382	204	599	172	519	30	150	76	268	162	493

Source: U.S. Geological Survey

1/ First period begins on April 1.

QUALITY ESTIMATES - OZARK WELL WATER (Preconstruction Conditions)

98 Percent Non-Exceedence Frequency or 50-Year Recurrence Interval (Concentrations in mg/l)

30-day period [1]	Well No. 1		Well No. 2		Well No. 3		Well No. 4		Well No. 5		Well No. 6		Composite	
	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids
1	227	665	72	278	172	522	145	452	30	150	44	168	135	419
2	216	638	58	225	170	517	141	440	30	150	31	154	125	398
3	204	606	76	272	168	511	127	404	30	150	44	186	121	388
4	220	643	66	244	173	524	132	417	30	150	35	164	124	394
5	225	654	47	194	170	516	116	374	30	150	30	150	115	371
6	234	674	48	196	175	526	107	352	30	150	30	150	114	366
7	258	732	55	214	187	554	110	357	30	150	30	150	121	383
8	297	823	61	229	206	602	124	391	30	150	30	150	135	418
9	323	887	72	256	222	639	136	422	30	150	30	150	147	448
10	353	959	94	312	246	696	167	498	30	150	39	174	171	507
11	387	1,042	133	409	273	763	212	610	30	150	57	220	205	591
12	426	1,138	171	504	301	831	268	747	30	150	75	267	244	687
13	435	1,161	270	751	337	919	365	990	30	150	127	397	308	846
14	425	1,137	403	1,083	376	1,016	424	1,134	30	150	207	598	363	982
15	390	1,054	400	1,077	405	1,087	431	1,152	30	150	226	645	368	996
16	331	913	286	795	380	1,028	424	1,134	30	150	179	527	334	912
17	279	789	179	528	333	911	409	1,099	30	150	118	373	292	808
18	256	733	143	439	287	798	315	865	30	150	96	318	237	673
19	252	724	126	396	254	720	252	710	30	150	83	285	202	588
20	250	720	107	347	233	668	215	621	30	150	67	245	180	532
21	246	708	97	322	221	639	179	531	30	150	58	222	160	484
22	247	709	98	324	216	628	166	499	30	150	59	225	155	471
23	253	725	114	366	215	625	167	504	30	150	73	259	160	485
24	265	756	125	395	216	628	180	539	30	150	81	281	170	512

Source: U.S. Geological Survey

[1] First period begins on April 1.

Table 6-2

QUALITY ESTIMATES - OZARK WELL WATER (Postconstruction Conditions)

50 Percent Non-Exceedence Frequency or 2-Year Recurrence Interval (Concentrations in mg/l)

30-day period [1]	Well No. 1		Well No. 2		Well No. 3		Well No. 4		Well No. 5		Well No. 6		Composite	
	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids
1	130	433	143	469	144	464	140	459	112	361	123	390	135	440
2	122	414	141	464	135	443	131	437	122	385	125	394	129	426
3	126	424	133	447	126	420	126	426	133	410	125	394	126	419
4	131	436	129	437	126	420	131	437	136	419	122	386	128	423
5	145	468	130	439	130	430	135	449	127	397	117	374	132	432
6	151	482	136	453	135	443	141	461	124	389	117	375	136	442
7	146	471	141	464	145	466	144	473	123	387	116	371	138	448
8	142	461	147	478	142	459	145	471	129	400	118	377	138	447
9	142	461	142	466	142	459	143	466	134	415	124	392	138	448
10	144	466	141	464	141	457	141	461	126	395	124	390	138	446
11	150	480	143	469	145	466	145	471	108	351	123	387	141	452
12	144	466	145	473	148	473	145	471	99	331	123	387	140	451
13	130	433	143	469	144	464	140	459	112	361	123	390	135	440
14	122	414	141	464	135	443	131	437	122	385	125	394	129	426
15	126	424	133	446	126	420	126	426	133	410	125	394	126	419
16	131	436	129	437	126	420	131	437	136	419	122	386	128	423
17	145	468	130	439	130	430	135	449	127	397	117	374	132	432
18	151	482	136	453	135	443	141	461	124	389	117	375	136	442
19	146	471	141	464	145	466	144	473	123	387	116	371	138	448
20	142	461	147	478	142	459	145	471	129	400	118	377	138	447
21	142	461	142	466	142	459	143	466	134	415	124	392	138	448
22	144	466	141	464	141	457	141	461	126	395	124	390	138	446
23	150	480	143	469	145	466	145	471	108	351	123	387	141	452
24	144	466	145	473	148	473	145	471	99	331	123	387	140	451

Source: U.S. Geological Survey.

[1] First period begins on April 1.

QUALITY ESTIMATES - OZARK WELL WATER (Postconstruction Conditions)

80 Percent Non-Exceedence Frequency or 5-Year Recurrence Interval (Concentrations in mg/l)

30-day period [1]	Well No. 1		Well No. 2		Well No. 3		Well No. 4		Well No. 5		Well No. 6		Composite	
	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids
1	130	433	143	469	144	464	140	459	112	361	124	392	135	441
2	122	414	141	464	135	443	131	437	122	385	124	390	129	405
3	140	456	133	446	126	420	130	435	133	410	126	396	130	408
4	155	494	131	441	133	439	139	456	136	419	124	390	137	444
5	173	535	141	464	143	461	154	492	127	397	119	380	147	468
6	180	552	153	492	155	491	166	521	124	389	116	371	155	486
7	177	544	161	512	165	514	171	533	123	387	121	384	159	497
8	173	535	167	527	168	520	174	540	129	400	128	400	160	504
9	172	533	165	522	169	523	174	540	134	415	130	420	164	509
10	180	552	165	522	169	523	175	542	126	395	139	427	166	514
11	185	563	167	527	171	529	178	549	100	333	138	429	166	519
12	178	547	171	536	176	541	179	552	99	331	141	431	169	521
13	162	502	175	547	173	534	172	535	131	406	143	435	164	502
14	151	482	168	529	164	512	162	511	144	439	146	444	157	493
15	141	459	159	503	151	482	151	485	160	476	146	444	149	473
16	145	468	152	491	145	466	145	471	165	488	146	444	146	465
17	154	490	150	485	142	459	149	480	153	458	139	427	147	467
18	159	502	152	490	145	466	150	483	152	456	132	411	147	468
19	150	480	156	500	149	475	150	483	150	452	130	404	146	465
20	145	468	158	505	147	471	148	478	159	472	131	408	144	462
21	146	471	153	492	145	466	145	471	165	488	134	414	143	459
22	148	475	150	485	145	466	145	471	154	461	135	417	144	460
23	150	480	149	483	145	466	145	471	131	406	131	403	143	458
24	144	466	152	490	150	477	145	471	122	385	129	402	142	455

Source: U.S. Geological Survey.

[1] First period begins on April 1.

QUALITY ESTIMATES - OZARK WELL WATER (Postconstruction Conditions)

90 Percent Non-Exceedence Frequency or 10-Year Recurrence Interval (Concentrations in mg/l)

30-day Period [1]	Well No. 1		Well No. 2		Well No. 3		Well No. 4		Well No. 5		Well No. 6		Composite	
	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids
1	130	433	142	469	144	464	140	459	112	361	124	398	135	441
2	122	414	141	464	135	443	131	437	122	385	124	390	129	425
3	153	487	133	446	126	420	135	447	133	410	126	396	135	438
4	176	542	134	448	139	453	151	485	136	419	124	390	146	466
5	197	593	150	485	156	494	173	538	127	397	119	380	161	502
6	208	620	167	527	172	532	189	576	124	389	118	377	172	529
7	203	606	180	556	189	571	197	595	123	387	128	400	180	547
8	203	608	187	573	191	577	201	604	129	400	137	423	185	559
9	201	603	186	571	194	584	202	607	134	415	149	450	188	565
10	211	627	188	575	194	584	203	609	126	395	155	464	191	573
11	217	641	192	586	200	597	208	621	100	333	155	466	190	569
12	209	622	198	600	204	607	210	626	99	331	158	472	190	565
13	191	579	201	607	202	602	203	609	148	446	160	476	191	573
14	175	540	194	591	189	571	189	576	165	488	165	489	185	551
15	157	497	186	571	176	541	172	539	185	534	167	493	170	523
16	155	492	173	542	162	507	160	507	190	548	164	487	161	503
17	160	504	167	546	156	494	160	507	177	516	159	474	160	500
18	164	513	166	524	157	495	159	504	175	512	150	454	158	95
19	154	490	167	527	156	494	157	499	175	510	143	438	154	456
20	147	473	168	529	152	484	154	492	185	536	144	439	152	479
21	146	471	162	515	151	479	148	478	192	549	147	445	148	473
22	149	478	159	508	149	475	145	471	180	522	144	439	147	468
23	153	487	156	500	150	477	150	483	155	465	139	421	149	472
24	144	466	157	503	151	479	148	478	145	441	136	430	146	465

Source: U.S. Geological Survey.

[1] First period begins on April 1.

QUALITY ESTIMATES - OZARK WELL WATER (Postconstruction Conditions)

95 Percent Non-Exceedence Frequency or 20-Year Recurrence Interval (Concentrations in mg/l)

30-day period 1/	Well No. 1		Well No. 2		Well No. 3		Well No. 4		Well No. 5		Well No. 6		Composite	
	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids
1	130	433	143	469	144	464	140	459	112	361	124	390	135	440
2	122	414	141	464	135	443	131	437	122	385	125	394	129	426
3	168	523	133	446	126	420	139	457	133	410	125	394	138	448
4	196	591	138	459	148	473	164	516	136	419	122	386	156	489
5	227	665	161	512	171	527	193	585	127	397	117	374	176	537
6	241	697	183	563	193	582	218	645	124	389	124	392	195	582
7	237	686	200	602	212	627	229	671	123	387	138	425	206	603
8	236	685	211	632	220	645	233	680	129	400	150	454	211	622
9	237	688	211	632	221	650	233	680	134	415	166	499	215	631
10	246	709	212	634	223	652	235	685	126	395	171	503	219	639
11	255	731	221	654	229	666	240	702	108	351	174	509	225	654
12	246	709	227	669	237	686	246	711	99	331	178	509	228	660
13	222	653	231	678	233	674	235	685	169	496	182	530	220	643
14	207	617	226	666	219	640	219	647	190	546	185	536	210	617
15	174	537	215	642	205	609	199	599	212	600	192	553	195	583
16	166	518	203	612	183	556	181	557	220	619	189	546	182	552
17	167	521	188	575	171	527	170	530	205	583	183	532	174	531
18	168	523	184	566	167	518	166	521	203	577	174	509	170	522
19	158	497	182	561	166	516	163	514	203	577	160	476	163	507
20	150	480	183	563	160	502	159	504	216	609	159	474	160	493
21	146	471	172	542	156	494	153	490	225	629	161	478	156	489
22	149	478	169	531	155	491	149	480	210	596	153	460	152	481
23	153	487	163	520	155	491	151	485	181	526	149	450	152	481
24	146	471	163	520	158	497	149	480	169	496	147	445	150	476

Source: U.S. Geological Survey.

1/First period begins on April 1.

Table C-2 (continued)

QUALITY ESTIMATES - OZARK WELL WATER (Postconstruction Conditions)

98 Percent Non-Exceedence Frequency or 50-Year Recurrence Interval (Concentrations in mg/l)

30-day period[1]	Well No. 1		Well No. 2		Well No. 3		Well No. 4		Well No. 5		Well No. 6		Composite	
	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids	Chloride	Dissolved solids
1	130	433	143	469	144	464	140	459	112	361	159	474	143	459
2	122	414	141	465	135	443	131	437	122	385	163	484	138	446
3	190	577	133	446	126	420	146	473	133	410	169	499	155	486
4	229	670	144	471	158	497	183	561	136	419	174	511	182	552
5	269	762	175	547	192	579	223	657	127	397	178	520	213	624
6	289	811	206	620	224	654	254	733	124	389	184	533	236	681
7	286	804	230	676	250	715	270	770	123	387	201	575	251	717
8	283	797	245	713	266	740	278	789	129	400	212	602	259	735
9	286	804	247	717	264	750	280	794	134	415	220	621	263	744
10	297	830	252	729	266	754	283	801	136	395	224	629	267	754
11	308	856	262	750	273	772	290	817	108	351	219	616	272	765
12	293	834	270	771	282	792	293	825	99	331	211	591	272	765
13	268	762	274	781	277	781	282	793	197	564	205	584	261	740
14	249	716	271	774	264	750	264	756	224	628	200	571	248	702
15	196	591	259	745	247	702	235	685	253	697	195	560	223	650
16	182	556	241	703	213	630	203	609	265	725	185	536	200	594
17	180	552	216	644	192	579	189	576	245	679	168	495	186	560
18	176	542	208	625	184	559	177	549	243	674	149	450	174	534
19	163	511	203	612	179	548	171	533	244	675	124	392	163	507
20	154	490	203	612	170	525	165	518	259	711	117	374	157	491
21	151	482	190	581	164	512	157	499	271	739	122	386	152	480
22	152	485	181	559	162	507	154	492	253	697	125	394	151	477
23	153	487	176	549	161	505	154	492	218	613	125	394	150	476
24	145	471	174	544	162	507	152	487	204	580	124	390	148	470

Source: U.S. Geological Survey.

[1] First period begins on April 1.